PECULIARITIES OF THE ACTION OF MICROBIAL FERTILIZERS FROM LIVESTOCK WASTE IN "SOIL-PLANT-MICROORGANISMS" SYSTEM

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ABSTRACT

Modern biotechnology allows using microorganisms to process livestock farm waste into effective microbial fertilizers. These types of fertilizers appeared at the end of the XX-th century and since than have been used in sustainable agriculture. They combine positive features of both mineral and organic fertilizers and do not have their shortcomings. However, the mechanism of microbial fertilizer action in the system "soil-plant-microorganisms" is not studied yet.

Our research showed that microbial fertilizers applied into soil in comparatively small rates (1-2 t/ha) effect the "soil-plant" complex not only due to the introduced plant nutrient elements (as mineral fertilizers), but also due to the activation of soil microflora with acceptable organic matter. As the result, the following soil parameters increased: intensity of mineralization processes; humus synthesis; carbon and nitrogen immobilization in microbial biomass. All these led to soil fertility increase and ensured the effect of microbial fertilizers on soil for further several years.

The results obtained served as a scientific ground for the application of microbial fertilizers not only in sustainable agriculture, but also in the reclamation of contaminated soils.

INTRODUCTION

Recently new types of fertilizers: microbial fertilizers produced by microbiological transformation of livestock and poultry farm waste in fermenters, have been successfully used in agriculture (Arkhipchenko, 2002, 2003). These fertilizers possess high content of main plant nutrient elements and phyto-sanitary effect, contain active complex of farm-useful microorganisms and metabolites and prove to be more effective than NPK and even manure when added in equal nitrogen content portions (Derikx and Arkhipchenko, 1999; Fisinin and Arkhipchenko, 2001). Taking into account that these fertilizers are absolutely novel and can be described by positive features of both mineral (known and constant element content, low application rate, high nitrogen concentration, etc.) and organic fertilizers (aftereffect, positive effect on biological properties, etc.) there arises a necessity to study the mechanism of their action in "soil-plant-microorganisms" system.

MATERIALS AND METHODS

Microbial fertilizers produced by aerobic treatment of pig farm waste water (Bamil), aerobic fermentation of litter poultry dung (Omug), anaerobic fermentation of litter-free poultry dung (Ecud) and poultry dung dried under IR rays (Pudret) were studied. Under field and pot conditions their effect on crop yield, biological activity of soils, size of microbial biomass, number of useful groups of microorganisms, carbon and nitrogen balance in soil and remediation of oil-contaminated soils were examined.

Amount of microorganisms and their activity, respiration, microbial biomass and organic matter content in soils were determined by known methods (Alef and Nannipieri, 1998).

RESULTS AND DISCUSSION

Mechanism of polyfunctional action of microbial fertilizers (fig. 1) is associated with the action of microorganisms both added with the fertilizer and soil ones. Traditional organic fertilizers added at the rates of 30-40 t/ha differ from the fertilizers in their mechanism of action: due to their great amount of fresh organic matter applied directly into soil they effect soil physical properties and transfer it, though temporally, to the different energy level. Microbial fertilizers added in relatively small amounts (1-4 t/ha) effect soil-plant complex not only due to the applied plant nutrient elements (like mineral fertilizers), but also due to activation of soil microflora with available organic matter. Simultaneously, not only mineralization processes are intensified, but also humus synthesis, C and N immobilization in microbial biomass increase, which lead to soil fertility increase and provide for aftereffect.

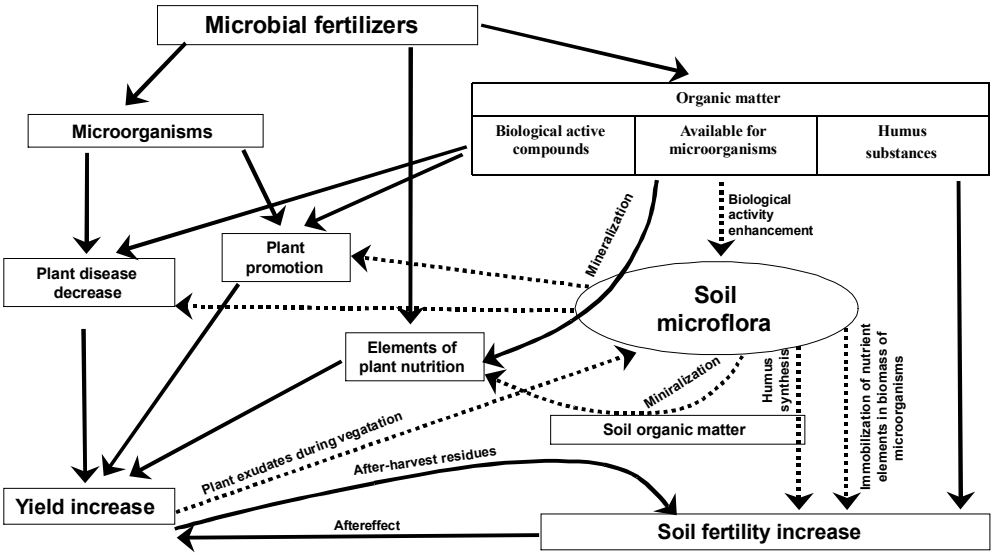

Figure 1. *Polyfunctional effect on soil-plant complex.*

Table 1. *Effect of different types of fertilizers on total and active microbial biomass sizes in pot experiment (ray-grass, 40th day of experiment).*

Fertilizers	Variant s	Biomass carbon, mg/kg		Active biomass % of total
		Total	Active	
Traditional	ĐÊ	542	284	52.4
	NPK	551	328	59.5
	Livestock manure	574	338	58.9
Microbial	Bamil	630	421	66.8
	Ecud	684	545	79.7
	Pudret	605	507	83.8
Composts	Straw compost	774	198	25.6
	Municipal compost	647	146	22.6
	Vermicompost	727	156	21.4
	$LSD_{p\leq0.05}$	88	69	

Increase in biomass of active microorganisms (method of substrate-induced respiration) in soil after microbial fertilizers application is shown in table 1. Composts increase total microbial biomass (fumigation method), active biomass is only 20-25% in comparison with 70-80% when microbial fertilizers are added.

When microbial fertilizers are added not only total amount of microorganisms, but also the amount of useful groups of microorganisms in the rhisosphere increase (table 2). The amount of physiologically active substances' producers and the number of microorganisms suppressing phytopathogens increase, and simultaneously, the number of phytotoxic species reduces.

Table 2. *Effect of microbial fertilizers on the number and quality composition of rhisosphere microflora.*

Variant	Total Microbial Amount (TMA) mln./g a.d.m.	Amount of antagonist and produ cers of physiologically active substances, % of TMA			
		Producing vitamins	Producing IAA	Antagonists	Phytotoxic
Control	176	3.8	10.9	3.1	15.3
NÐÊ	192	12.0	9.3	15.5	16.8
Bamil	253	19.2	23.2	24.6	5.8
Omug	180	14.7	18.4	30.3	3.3
Pudret	228	33.0	40.0	33.0	4.9

As the main role in the action of microbial fertilizers in soil is played by microorganisms (both from fertilizers and soil ones) specific attantion should be paid to the effect of these fertilizers on organic matter and its availability for microorganisms. It was shown that in order to form a rhisosphere complex of microorganisms, the availability of organic matter from the fertilizers plays a great role (table 3).

Table 3. *Effect of availability of organic matter of fertilizers on ray-grass yield and amount of rhizosphere microorganisms.*

Variants	Availability of organic matter of added fertilizers % $Ñ_{avail}$ î ò $Ñ_{tot}$	Ray-grass yield (dry weight) g/pot	Amount of rhizosphere microorganisms mln. CFU/ g a.d.s.
Control	-	10.7	176
Bamil	43.5	18.4	253
Omug	25.7	16.8	180
Pudret	41.9	17.3	228

Microbial fertilizers possess modifying action on soil processes. They increase humus substances synthesis in soil by 14-46% and the portion of easily-available for microorganisms organic substances in comparison with mineral fertilizers. As the result of humifying processes intensification after Bamil is applied, no reduction in total humus content takes place, though in control and NPK humus reduction accounts for 0.12-0.19% of soil weight.

Microbial fertilizers Omug and Bamil can be used as effective biopreparations to treat oil-contaminated soils, as they contain 10^3-10^4 CFU microorganisms-oil-destructors, and, besides, they are good carriers for introduced microorganisms. As the result, complex biopreparations are produced, combining the approaches of bio-augmentation and bio-stimulation. Field trials of produced preparations proved an increase in oil content in soil by 71-94% during vegetation period.

CONCLUSIONS

Hence, differences in the efficiency of studied biofertilizers depend on their content, availability for soil microorganisms and nutrient elements balance.

Main peculiarities of the action of microbial fertilizers in "soil-plant-microorganisms" system are:

- activation of soil microflora, increase in the portion of mictoorganisms producing physiologically active substances: plant growth promoters, and microorganisms-antagonists of phytopathogenic microflora;
- increase in synthesis of humus substances by 14-46%;
- ability to increase soil fertility, stimulate native alkanotrophic microflora and sustainability of introduced microorganisms provides for oil-destruction by 71-94% and reclamation of contaminated soils.

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